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**SEMI-ANNUAL TECHNICAL SUMMARY**  
for the period ending 28 February 1970

to

**ADVANCED RESEARCH PROJECTS AGENCY**

**RESEARCH OF AEROPHYSICS INSTITUTE  
FOR STRATEGIC TECHNOLOGY**

**ARPA Order No. 1442**

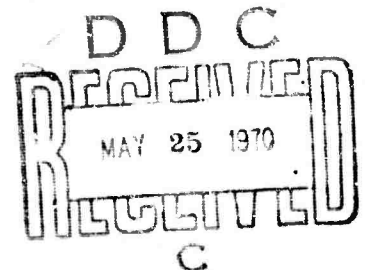
**Program Code No. 9E30**

**PIBAL  
Report 70-28**

for  
**U.S. Army Research Office - Durham  
Contract No. DAHCO4-69-C-0077**

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**POLYTECHNIC INSTITUTE OF BROOKLYN**

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RESEARCH OF AEROPHYSICS INSTITUTE  
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Date of Contract: 1 September 1969

Expiration Date: 31 October 1970

PIBAL  
Report 70 28

for  
U.S. Army Research Office-Durham  
Contract No. DAHCO4-69-C-0077

Submitted by: Martin H. Bloom  
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Director of Gas  
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Dean of Engineering

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#### ACKNOWLEDGEMENT

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### ABSTRACT

This report contains a compilation of abstracts of papers which were either accepted for publication or were published. The papers are on subjects of Fluid Dynamics, Electromagnetics and Plasmas. The work described was carried out under an ARPA contract, Order No. 1442. This summary also contains a listing of papers submitted to journals, lectures, internal reports and staff activities.

## I. INTRODUCTION

The Polytechnic Institute of Brooklyn is conducting an interdisciplinary program involving both theoretical and experimental research in the areas of aerodynamics, plasma dynamics and turbulence. These studies are generally applicable to both current and long-range interests of the ARPA Strategic Technology Office. Particular emphasis is placed on items relating to defense situations.

## II. SUMMARY OF RESEARCH PUBLICATIONS

In this section are presented abstracts of technical papers which have been either published or accepted for publication during the reporting period covered by this report.

### A. Fluid Dynamics

G. Moretti, "The Importance of Boundary Conditions in the Numerical Treatment of Hyperbolic Equations", published in The Physics of Fluids, Suppl. II, 12, 12, Part II., December 1969.

Many of the existing computations of initial- and boundary-value problems in fluid mechanics suffer from unrealistic treatment of boundary points. Three categories of boundaries are discussed briefly: rigid walls, arbitrary boundaries of a computational region in a subsonic flow, and shock waves. An attempt is made to show in what sense the numerical treatment of such boundaries may be physically wrong and what can be done instead. Examples from the blunt body problem, the transonic flow in a nozzle, the incompressible inviscid flow past a circle, and the quasi-one-dimensional flow in a laval nozzle, are shown.

S. Lederman, M.H. Bloom, and J. Avidor, "The Electrostatic Probe: Some Applications to Hypersonic Flow Diagnostics", to be presented and published in the Proceedings of the Twelfth Israel Annual Conference on Aviation and Astronautics, held in Tel Aviv, March 4-5, 1970.

Results of an experimental investigation of the applicability of electrostatic cylindrical probes for flow field diagnostics are presented. An experimental extension of the formulation of the free-molecular collisionless operation of cylindrical probes into the transitional and continuum regime is provided. It is shown that the power law valid for the free molecular collisionless regime with  $0.1 < \frac{I_p}{I_0} < 1$  is applicable in the transitional and continuum regime where  $\frac{I_p}{I_0}$  may exceed 1. Experimental results obtained in the wake of several models, using the electrostatic probe technique, are compared with results obtained by other means. These results confirm the basic principle and soundness of this technique.

### 3. Plasmas

H. Friedman and E. Levi, "Plasma Shielding", accepted for publication in The Physics of Fluids.

Necessary and sufficient conditions are established for the shielding of current-carrying plasmas by means of space charge sheaths. These conditions reduce to Bohm's shielding criterion in the particular case of zero current and in general are consistent with measurements obtained by means of Langmuir probes and their current interpretation.

III. ARPA-RELATED ACTIVITIES, LECTURES, CONSULTANTS, PAPERS  
SUBMITTED TO OUTSIDE JOURNALS, AND INTERNAL REPORTS

A. ARPA-Related Activities

Dean Martin H. Bloom is a member of the Atomic and Molecular Physics Panel of the Institute for Defense Analyses (IDA); Associate Editor of the Journal of Ballistic Missile Defense Research, published by IDA for ARPA; and is a member of the AIAA Technical Committee on Entry Vehicles.

Professor Robert J. Cresci is a member of the AIAA Ground Test and Simulation Technical Committee, and was a Session Chairman at the AIAA 6th Aerospace Sciences Meeting, held in New York, January 19-21, 1970.

Participation at meetings relevant to the program:

September 1969:

- (a) L. B. Felsen presents an invited survey paper entitled "Ray Methods for Propagation and Scattering in Waveguides", at the 1969 European Microwave Conference, London, England, September 8-21, 1969.
- (b) J. Griemsmann attended a BMD Meeting held in Washington, D. C., September 25, 1969.

October 1969:

- (c) S.F. Widhopf and S. Lederman are authors of a paper, "Individual Specie Concentration and Vibrational Temperature Measurements Utilizing Laser Induced Raman Scattering", which was presented at the 20th Congress of the International Astronautical Federation, held



at Mar del Plata, Argentina, October 5-21, 1969.

November 1969:

- (d) G. Moretti attended the Third Annual Aerodynamic Hyper-sonic Slender Cone Symposium, held in Arlington, Va., November 21, 1969.

December 1969:

- (e) M.H. Bloom attended the AIAA Strategic Offensive/Defensive Missile Systems Meeting, held at the Naval Postgraduate School, Monterey, California, December 1-3, 1969.
- (f) M.H. Bloom participated in an ARPA laser design review, held at AVCO-Everett, Everett, Mass., December 17-18, 1969.

January 1970:

- (g) PIB-ARPA Workshop on "Gas Dynamics from a Numerical Standpoint", held at City University, New York, January 17, 1970.

Participants included:

Robert Moore - Advanced Research Projects Agency  
 F.L. Fernandez and M.H. Steiger - Aerospace Corporation  
 Michael Abbett - Aerotherm Corporation  
 Roberto Vaglio-Laurin - Advanced Technology Labs., Inc.  
 John G. Trulio - Applied Theory, Inc.  
 Dr. Magnus - General Dynamics Corp., Convair Div.  
 Paul Gordon - G.E., Valley Forge Space Tech. Center  
 N. D'Souza - McGill University  
 John V. Rakich - NASA Ames Research Center  
 S.Z. Burstein - New York University

S. A. Powers - Northrop Aircraft Div.

Thomas Taylor - Northrop Corporate Labs.

Morton Cooper - Office of Naval Research

C. Kentzer and Dr. Thompson - Purdue University

Raymond Sedney - Research Institute for Advanced Studies

M.H. Bloom, G. Moretti, R. Cresci, S.G. Rubin, E.L. Rubin,

P.K. Khosla - Polytechnic Institute of Brooklyn

- (h) L. B. Felsen presented an invited seminar entitled "Transients in Dispersive Media" at Wayne State Univ., Detroit, Mich., January 26, 1970.
- (i) S. Lederman presented a paper entitled "Specie Concentration Measurements Utilizing Laser Induced Raman Scattering" (co-authored by G.F. Widhopf) at the AIAA 8th Aerospace Sciences Meeting, New York, N.Y., January 19-21, 1970.

#### B. Lectures

##### September 1969:

Dr. C. DuP. Donaldson  
Aeronautical Research  
Associates of Princeton, Inc.

Calculation of Turbulent  
Shear Flows Through Closure  
of the Reynolds Equations  
by Invariant Modeling

##### October 1969:

Prof. B.W. McCormick, Jr.  
Pennsylvania State University

The Structure of Trailing  
Vortices and the Rotor-  
Vortex Interaction Problem

Dr. James Vollmer  
RCA Advanced Technology Labs.

Applied Science, Technology  
and Curricula

Dr. Mario D. Grossi and  
Mr. Irwin Shear  
Raytheon Company

Electromagnetic Probing of  
Planetary Atmospheres and  
Ionospheres

D. Datorsky  
Polytechnic Institute of Brooklyn

Radiation from a Directive  
Source in an Inhomogeneous  
Duct

November 1969:

Prof. A.R. Seebass  
Cornell University

Generation and Propagation  
of Sonic Booms

Dr. Herbert J. Carlin  
Cornell University

Helicon Mode Semiconductor  
Devices

J. C. Bureau  
Polytechnic Institute of Brooklyn

Element Pattern for Circular  
Arrays of Waveguide-Fed  
Axial Slits on Large Con-  
ducting Cylinders

December 1969:

Dr. Y. Zhidko  
Gorki State University, USSR

Compression of FM Pulses  
Propagating in an Inhom-  
ogeneous Plasma

Dr. G.W. Sutton  
AWCO-Everett Research Laboratory

Fluid Mechanics Research at  
AWCO-Everett

Dr. E.L. Bertoni  
Polytechnic Institute of Brooklyn

The Local Properties of  
Radiation in Lossy Media

January 1970:

Prof. C.M. Tchen  
City College of the City  
University of New York

Cascade Model of Plasma  
Turbulence

Dr. W.D. Jones  
Oak Ridge National Laboratory

Some Basic Plasma Physics  
Research : Oak Ridge  
National Laboratory

Prof. Hans Wilhelmsson  
University of Uppsala, Sweden

Plasma and Related Research  
Activities at the University  
of Uppsala

February 1970:

Dr. J. Grey  
Greyrad Corporation

Diagnostics of High Tempera-  
ture Gas Flows

During the course of this six-month period, Professor N. Marcuwlz (of N.Y.U.) gave a weekly lecture series on Plasma Turbulence.

#### C. Consultants

Dr. Nathan Marcuvitz, Professor of Applied Physics,  
New York University.

#### D. Internal Reports

G. F. Widhopf and S. Lederman, "Species Concentration Measurements Utilizing Raman Scattering of a Laser Beam", PIBAL Report No. 69-46, Dept. of Aerospace Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn, November 1969.

M. Pierucci, "An Axisymmetric Near Wake Analysis Using Rotational Characteristics", PIBAL Report No. 70-4, Dept. of Aerospace Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn, February 1970.

Coordinated by M.H. Bloom, "Research of Aerodynamic Physics Institute for PROJECT STRATEGIC TECHNOLOGY". Semi-Annual Technical Summary for the period ending 31 August 1969, PIBAL-R-1295.9-69.

#### IV. PERSONNEL

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E. F. Dawson	Research Assistant

R. Eichler	Graduate Assistant, Senior Grade
H. Farber	Associate Professor
L.B. Felsen	Professor
J.W.E. Griemsmann	Professor
K. Huang	Graduate Assistant, Senior Grade
R.G.E. Hutter	Professor
E. Kawecki	Research Fellow, Junior Grade
P.K. Khosla	Assistant Professor
D. Landsberg	Research Fellow, Junior Grade
E. Levi	Professor
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R. Mons	Research Associate
G. Moretti	Professor
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P. Rosner	Research Fellow, Junior Grade
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## 13. ABSTRACT

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Dispersive media						
Electron density distributions						
Kinetic theory						
Langmuir probes						
Near wake						
Numerical techniques						
Plasma striations						
Raman scattering						
Shock tube diagnostics						
Test facilities						